Norton Park Building, Edinburgh

– feedback for designers and clients

- Redevelopment of redundant Grade II listed building to provide offices for charities
- Helping to regenerate an inner-city area of Edinburgh
- Electricity consumption better than good practice
- Gas consumption better than typical
- Project demonstrates commitment to use of environmentally preferable design and materials

BEST PRACTICE PROGRAMME
ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

OVERVIEW

The Norton Park Building in Edinburgh is a Grade II listed former school. It has been redeveloped to provide low-cost office accommodation for charities and voluntary organisations.

The Albion Trust, owners of Norton Park, wanted the redevelopment to meet high environmental standards and to minimise energy use. The result is that high levels of insulation have been installed along with secondary double glazing, highly efficient lighting and condensing boilers. The operation of the building is controlled by a building management system (BMS).

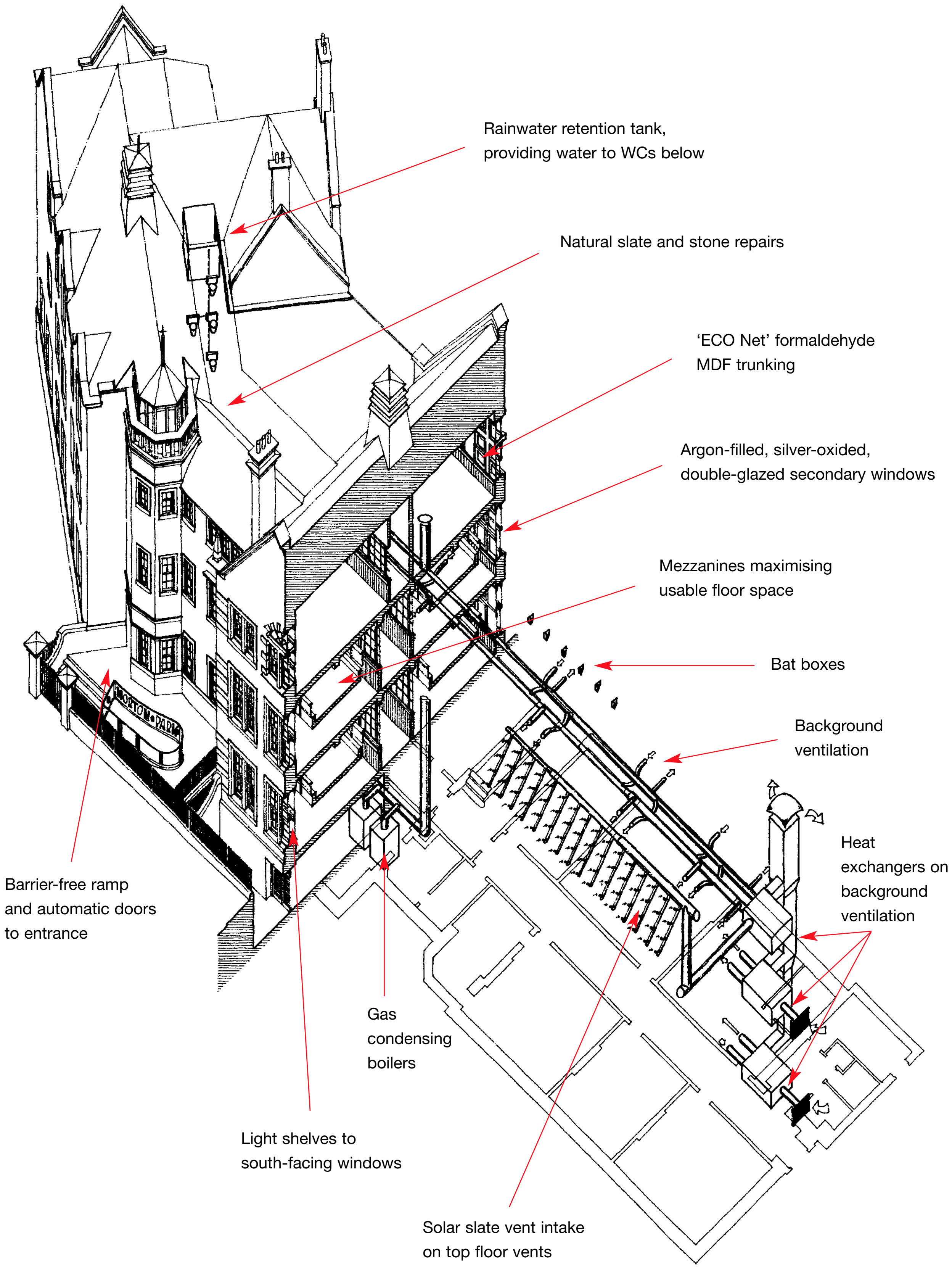
The building also uses a solar collector to preheat incoming ventilation air. The reuse of a redundant building is in itself an environmentally friendly way to provide accommodation. Wherever possible, local products and products with low embodied energy were used, and products using volatile organic compounds (VOCs) and PVC were avoided.

The building provides a central location for voluntary organisations in Edinburgh. with offices to a very high standard that are economical to run. The building has been fully let since it opened and there is a waiting list for offices.

The annual overall energy consumption of the building is 150 kWh/m^2, with electricity consumption better than good practice and gas consumption better than typical. The total energy consumption is less than the overall energy consumption of an equivalent good practice building in the Energy Efficiency Best Practice programme's (EEBPp's) Energy Consumption Guide (ECON) 19[1]. This is a considerable achievement that is not easily attained by many refurbishment projects. The building's associated carbon emissions are also low at less than 50 tonnes a year.

Occupants are generally happy with the building and feel that being in Norton Park benefits their organisations. Their only significant complaints are that in summer the offices are sometimes too hot and stuffy and the windows are difficult to open.

PLAN VIEW OF THE BUILDING



INTRODUCTION

'To ensure that Norton Park would be a flagship of best and innovative environmental practice, developed within a framework of economic practicality.'

THE BRIEF

The Norton Park Building in Edinburgh is a Grade II listed former school. It has been redeveloped to provide low-cost office accommodation for charities. The building is run by the Albion Trust, a charity set up specifically to manage its renovation and conversion.

In the early 1990s a number of charities in Edinburgh were in need of affordable office space. Lothian Regional Council suggested that one of Edinburgh's redundant schools might be suitable for conversion to provide this accommodation. Norton Park was selected as being the most suitable for the project.

The Albion Trust was formed to manage the redevelopment. Funds of £3 million were raised from 10 different sources to support the range of social, environmental and community benefits associated with the redevelopment.

The Albion Trust wanted the Norton Park redevelopment to embody high environmental standards. They produced a brief calling for a sustainable development where the environmental impact of all aspects of the building were assessed.

Figure 1 Office space on one of the mezzanine floors

The brief specified that this philosophy should be applied to:

- energy use
- construction materials
- lighting
- ventilation and cooling
- water consumption
- the redevelopment of the site.

THE DESIGN APPROACH

Architects (Burnett Pollock Associates) were commissioned to produce the design for the redevelopment. The Albion Trust worked with their architect, Richard Atkins, to ensure that they would get the accommodation they required and achieve the high environmental standards they had set.

The resulting design included the installation of mezzanine floors in the office areas. This enlarged the usable floor area and, by increasing the potential rental income, made the redevelopment financially viable.

The design also incorporated several low-energy technologies and environmentally preferable elements:

- additional insulation and secondary double glazing
- a new heating system utilising condensing gas boilers
- a heat recovery system incorporating solar technology
- measures to minimise water consumption
- the use of environmentally preferable construction materials.

The redevelopment was completed in 1998. It is now home to 25 voluntary organisations. The Albion Trust appointed a facilities manager to run the building in September 1999.

BUILDING DESCRIPTION

SITE
The Norton Park Building is situated in Edinburgh in an area of handsome Victorian tenements near the boundary with Leith. It is close to the city centre and served by public transport.

This inner-city area is quite run down and will benefit from the employment brought by the redevelopment.

FORM AND FABRIC
Norton Park is a red sandstone Grade II listed building with a black slate roof. It was originally a Board School designed by John Carfrae in 1903. When the Albion Trust took ownership of the building in 1995 it was structurally sound but in need of refurbishment.

During redevelopment, little change was made to the external appearance of the building: an existing extension was re-modelled, ramps were installed at entrances and the rear entrance was enlarged. The internal structure was altered to incorporate a large reception area, a nursery, conference rooms, interview rooms, a café, toilets and 28 office units for use by charities. Galleried mezzanine floors were built in the office units to increase the lettable area by 25%. The net lettable floor area of the building following the redevelopment is 3750 m^2.

The refurbishment was undertaken to meet the access requirements of everyone, including disabled people. Automatic doors were installed and WCs and showers were designed by the architects, who consulted the groups serving the needs of people with disabilities who were going into the building. The lift has Braille inscriptions and voice messaging.

To ensure that the building would be energy efficient, changes were made to its fabric.

- The walls and roof were highly insulated with mineral wool. Walls now have a U-value of 0.2 W/m^{2}K and the roof has a U-value of 0.1 W/m^{2}K.
- Wooden-framed, argon-filled double glazing was installed in addition to the original sash windows. The windows now have a U-value of 0.85 W/m^{2}K.

VENTILATION
As part of the redevelopment a mechanical ventilation system has been installed in the central core of the building. This provides minimum fresh air levels of one air change per hour. In warm weather the system can be run overnight to precool the building to maintain summer comfort. In cold weather the incoming air is heated to 20.5ºC. The system is fitted with heat exchangers to recover heat from the exhaust air.

A solar heating system devised by Edinburgh's Napier University makes use of air that is warmed by being drawn under the roof slates to preheat the air supply to the top floor of the building.

Windows in the building can be opened to provide natural ventilation and punkah fans are used to assist the circulation of fresh air.

HEATING
The existing boilers, dating from 1910, had to be replaced. Two gas-fired condensing boilers were installed to supply heat to radiators and to the air-handling units.

The building is divided into 15 heating zones controlled by room thermostats. All radiators, except for the original cast-iron ones situated in the corridors, are fitted with thermostatic radiator valves.

During the heating season the thermostats are set to 20.5ºC. The fresh air provided by mechanical ventilation is also heated to 20.5ºC.

Domestic hot water is heated by the boilers and stored in a calorifier.

MINIMISING WATER CONSUMPTION
During redevelopment, measures were installed to minimise the use of water. Rainwater from the roof is collected in a rainwater storage tank and used to supplement mains water for the flushing of WCs. Low-flush toilets and controlled-flush urinals were also fitted.

BUILDING DESCRIPTION

LIGHTING AND DAYLIGHTING

The Norton Park Building benefits from large high windows and daylight penetration is generally good to both the original floors and the mezzanines. However, the installation of mezzanines has restricted the access of daylight to some areas below them.

Light shelves have been fitted halfway down the windows with the aim of increasing light penetration and reducing glare. Light shelves are a simple device created by the architects, and consist of wooden shelves fitted halfway down the windows. Their angle can be increased or decreased manually by the occupants to improve light penetration. In practice these adjustments are rarely made and many of the shelves have been removed.

Figure 2 Main entrance

On the top floor four new roof lights have increased the level of daylight.

Lighting is provided by high-frequency fluorescent lamps in luminaries with reflectors. Switches allow the lights closest to the windows to be controlled separately from those in the interior areas of the offices. Sensors automatically switch off lighting in individual offices and meeting rooms when no movement has been detected for a set period of time. The time delay on the lights turning off can be adjusted.

ENERGY MANAGEMENT

Energy management is through a BMS, which co-ordinates, monitors and controls the heating and ventilation operation. A separate lighting control system gives the operator the ability to control each light individually.

CONTROL STRATEGY

The Norton Park Building is heated to 20.5ºC from 7.30 am to 3.00 pm on Monday to Thursday and from 7.30 am to 2.00 pm on Fridays.

ENVIRONMENTALLY PREFERABLE DESIGN AND PRODUCTS

The renovation and reuse of a redundant building is an economical and environmentally friendly way to provide accommodation. The Albion Trust could not afford to construct a new building for its requirements, nor could they have found a suitable site. The redevelopment of Norton Park School, a Grade II listed building, also preserved its exterior and saved it from dereliction. Funding was available for a percentage of the restoration work because of the building's listed status.

The Norton Park Building's inner-city location gives convenient access to public transport, an environmentally preferable alternative to the car.

The Albion Trust worked with the architects to ensure the redevelopment was as environmentally friendly as possible, minimising any detrimental effects on the environment. Measures taken included the salvage and reuse of products and materials. This has included wall tiles, radiators, doors, wainscoting, floorboards, stone and slate tiles. The original sinks and WCs were sold for reuse.

BUILDING DESCRIPTION

The specification for the materials and components required that wherever possible:

- products were to be obtained from local suppliers to minimise transport costs and fuel use
- second-hand materials were to be used
- timber and timber products were to be from sustainable sources
- construction materials with low embodied energy were to be selected, such as glulam beams rather than steel
- products linked with sick building syndrome, including PVC, were to be avoided
- natural fibre carpeting, linoleum and water-based paints were used.

Construction was undertaken with consideration for the easy removal and recycling of building products at a future date. Wildlife diversity was encouraged with the provision of bat boxes.

SOCIAL ADVANTAGES

The redevelopment of Norton Park has provided high-quality, low-cost office accommodation for the voluntary sector. The development is the only one of its kind in Edinburgh and it provides a number of social benefits:

- a greatly improved work environment for the occupants with shared facilities such as meeting and conference rooms that individual charities could not have afforded
- housing the charities in one building makes it easy for them to communicate and reduces travel time and cost
- facilities to allow easy access and use of the building by all occupants and visitors
- the project has brought employment to, and helped revitalise, a run-down inner-city area.

Figure 3 Bat boxes on the roof

PERFORMANCE IN USE

ENERGY MANAGEMENT AND OPERATION

After redevelopment, during the first year of occupation, no-one was assigned responsibility for the energy management and operation of the Norton Park Building. Not surprisingly it was not operated as intended and, despite the energy-saving measures and technologies, energy consumption was high.

In September 1999 a facilities manager, Isabel Brown, was appointed. She was keen to minimise energy consumption. Her initial investigations unearthed a number of problems with the operation of the heating and ventilation systems that were contributing to the high energy bills. These included:

- heating set at 22ºC
- condensing boilers failing to condense
- boilers and ventilation running during the night
- frost protection working incorrectly
- optimiser controls on the heating not working correctly.

The facilities manager's priorities were to correct these operational problems and to find out how the building was intended to work through discussions with the building services engineers, the suppliers of the BMS and the installers of the heating system.

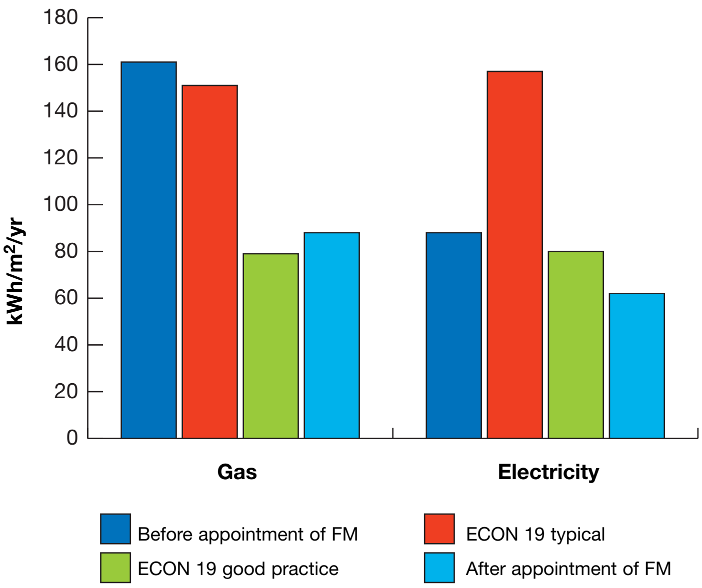


Figure 4 Comparison of energy consumption benchmarks

By the end of March 2000 the facilities manager had gained a thorough understanding of how the building was designed to function and had corrected the operational problems. With the building functioning correctly fuel consumption was greatly reduced.

The fuel consumption of the building has been compared to consumption in ECON 19. For this comparison the gas consumption of Norton Park has been normalised to the 20-year degree day average. The most appropriate benchmark was considered to be a Type 2 building with the fans, pumps and controls consumption of a Type 3 building.

Before the appointment of the facilities manager, energy consumption was 249 kWh/m^2/year. Since her appointment this has been reduced to 150 kWh/m^2/year. The carbon emissions associated with the energy used in the building were reduced from 80 tonnes a year to 50 tonnes a year. The energy consumption is compared to ECON 19 values in figure 4.

ENERGY CONSUMPTION

Electricity and gas consumption have been monitored on a half-hourly basis throughout the monitoring period. Figure 5 shows half-hourly electricity consumption for a typical week. It illustrates a regular pattern of usage with the load typically peaking at around 70 kW/h at between 10 am and 11 am, and dropping to a base load of 10 kW/h at weekends and during the night.

The base load was investigated and was mainly found to be fridges, PCs and other office equipment.

Figure 6 covers the same week as figure 5. Gas usage is highest when the heating first comes on in the morning. Figure 6 illustrates that the heating is now operating as originally intended.

- There is no gas used when heating is off at night and at the weekends.
- Gas usage peaks in the mornings when the building has to be brought up to temperature.
- Gas usage is highest on Mondays following the weekend when heating was off.

PERFORMANCE IN USE

Winter temperatures

Temperatures during the winter fluctuated between 15ºC and 23ºC, as can be seen from figure 7.

During office hours the temperature fluctuated between 19ºC and 23ºC – the lower temperatures seen on the chart are at weekends.

Summer temperatures

In summer the average temperatures fluctuated between 20ºC and 25ºC. This is acceptable, however there appears to have been some local overheating, particularly on mezzanine floors, which were generally two degrees warmer than the floors below.

Some occupants complained of difficulty opening windows and were using electric fans instead.

Figure 8 shows fairly constant average internal temperatures in summer.

SOLAR HEATING SYSTEM

Norton Park has a solar heating system that preheats ventilation air. The system works by drawing cold air from outside under south-facing roof slates. The slates are warmed by the sun and in turn they heat the incoming air.

Once the air has passed through the collector (figure 9) it is then conventionally heated (if necessary) before being distributed to the second floor offices.

The temperature of the outside air was compared to the temperature of the air once it had been warmed by being drawn under the roof slates. On average the temperature of the air was increased by 6ºC and on sunny days the solar collector increased the temperature of the intake air by as much as 20ºC, as shown in figure 10.

The solar collector was devised by Kerr MacGregor at Napier University in Edinburgh. Similar collectors are now commercially available.

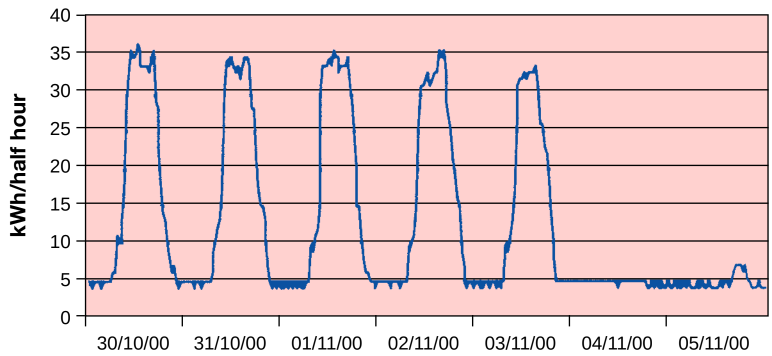


Figure 5 Electricity consumption from Monday 30th October to Sunday 5th November 2000

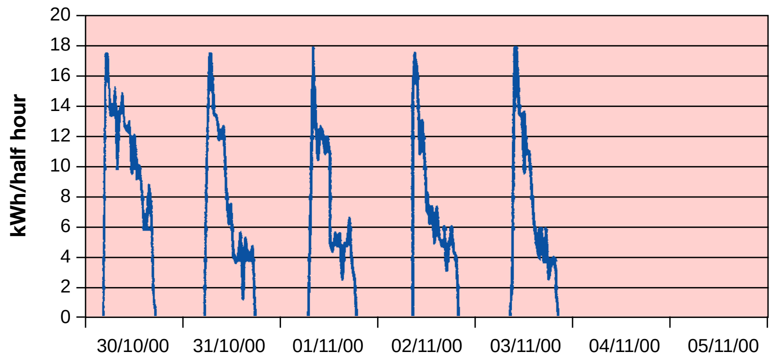


Figure 6 Gas consumption from Monday 30th October to Sunday 5th November 2000

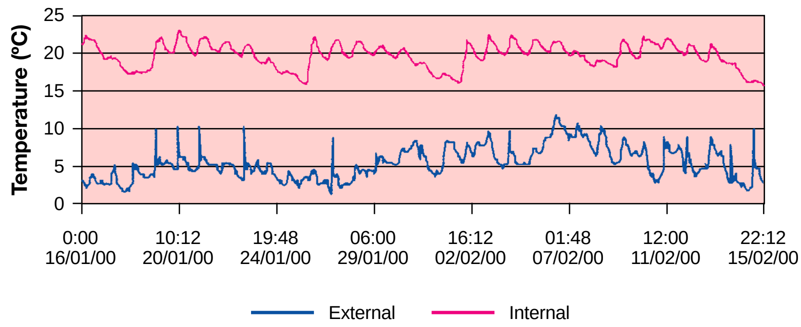


Figure 7 Average internal and external temperatures (January-February 2000)

PERFORMANCE IN USE

'An excellent initiative, which is only just beginning to pay dividends for all of us.'

'Norton Park is a great place to work and a good example to other organisations.'

'We often have clients referred to us from other groups and the number of visits we receive has more than doubled since moving here. It is much easier to share information and ideas.'

OCCUPANT ATTITUDES

At the beginning of the monitoring period occupants were surveyed about their attitudes to the building. They were asked about:

- the function of the building
- the quality of the office accommodation
- comfort levels
- control of their environment.

At the time this survey took place there were operational problems with the building's heating and ventilation. After these operational problems had been rectified and the building was functioning as intended, a smaller survey was carried out. This survey focused on comfort levels.

A number of respondents complained about comfort levels in the first survey. The second survey indicated that many of these issues had been resolved once the building's services were functioning correctly.

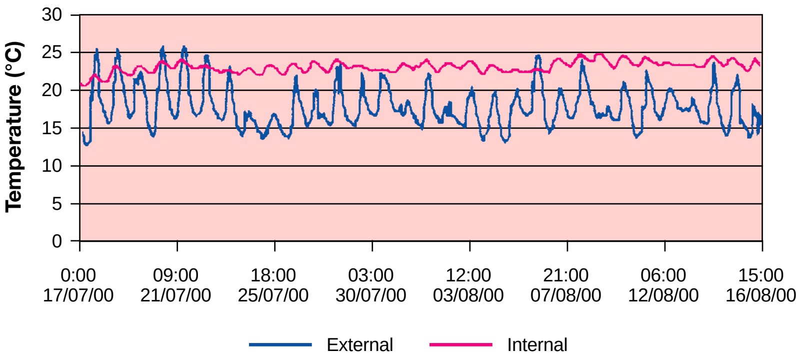


Figure 8 Average internal and external temperatures (July-August 2000)

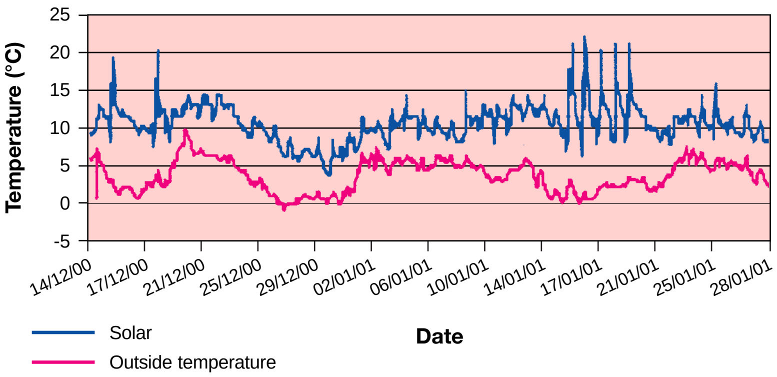


Figure 10 Solar collector

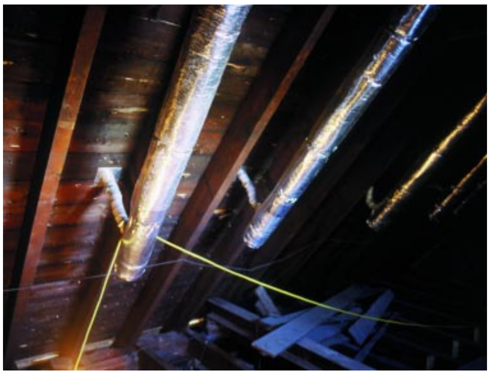


Figure 9 Solar heating system collector

Function of the building

Norton Park was converted to house a number of voluntary-sector organisations under the same roof. It was envisaged that being in close proximity to one another would benefit the organisations.

Seventy-six percent of respondents said they benefited from being close to the other organisations in the building and 68% said this saved them time. However, most were unable to say how much time was saved.

The additional benefits of proximity that were mentioned included:

- networking
- sharing knowledge, skills and resources
- learning about other organisations
- dropping in on other organisations
- a good atmosphere
- referring clients to other organisations.

Appearance and facilities

Appearance

Most respondents liked working in a historic building. A large number were delighted with the building's appearance and most were satisfied with the layout and fittings.

Accessibility

The Norton Park conversion incorporated measures to make the building accessible to everyone. Twenty-seven percent of respondents said that they benefited from these measures and a number of respondents said the measures were of benefit to clients. Some complaints were made about the gradient of ramps and inadequate lighting, and signing for people with visual impairment.

PERFORMANCE IN USE

Meeting facilities

Norton Park has seven meeting rooms available, two of which seat 30 people. Most respondents were satisfied with the meeting facilities provided, although some would have liked their own meeting rooms. A few respondents expressed a need for larger meeting rooms and better sound proofing.

Location

Norton Park has an inner-city location but it is not in the centre. Sixty-three percent of respondents found their journey to work easy and only 15% found it difficult. About 60% of respondents came to work by car. Most of the remaining 40% used buses or walked to work.

Some respondents commented that, being outside the city centre, Norton Park was not on a direct bus route and they had to catch two buses. Some respondents with mobility problems said public transport was not an option for them; therefore they had to use cars.

INFRARED THERMOGRAPHIC SURVEY

A thermographic survey of the Norton Park Building was carried out to identify any areas of heat loss. The survey identified problems with the secondary glazing and some problems with both the wall and the roof insulation.

- There was cold air leakage into the building around the secondary glazing. This air leakage is due to a lack of adequate sealing around the units and constitutes a significant area of heat loss.
- There were cool strips on the top floor ceiling indicating that there are areas of poorly laid insulation and gaps in insulation in the roof. These defects are not causing major heat loss and would be easy to rectify.
- Cool strips and patches on the walls indicated that in some areas insulation is missing or defective. The heat loss resulting from this is not major and would not be cost-effective to rectify.

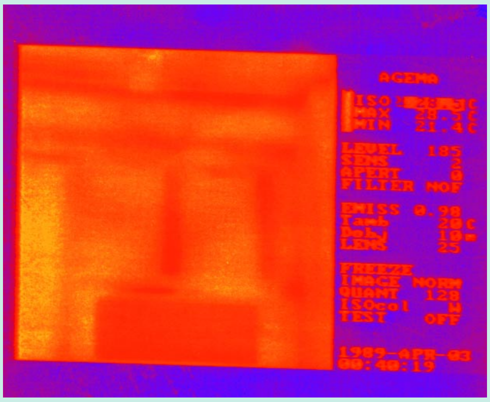


Figure 12 Thermograph of top floor ceiling – dark areas correspond to gaps and poorly laid insulation

HOW IT WORKS

In a thermographic survey, an infrared camera is used to scan the surfaces of a building. Pictures appear in greyscale (colour is added later) and the differences in the tones of grey correspond to differences in surface temperature.

The infrared camera can locate changes in surface temperature that result from lack of insulation or air leakage. Surface temperature differences of the order of 0.5ºC can be identified.

Figure 11 Thermograph showing cold air infiltration (blue) around secondary glazing with corresponding photograph of window frame

PERFORMANCE IN USE

'During the first winter in the building our office was very cold. Since then there has been a vast improvement.'

Comfort levels in winter and summer

Winter

The first survey demonstrated that, overall, respondents were not happy with the temperatures in winter. Only 17% considered that office temperatures were comfortable all the time, while 54% found it too hot some or all of the time and 78% found it too cold some or all of the time.

A second occupant survey was carried out after the problems with the heating and ventilation systems had been rectified. In this survey 63% of respondents considered that office temperatures were comfortable all the time. Most of the remaining 37% said that their offices were too cold sometimes. However, a large number commented that cold offices were only an occasional problem and that there had been a big improvement since their first winter in the building.

In the initial survey 62% of respondents said they were happy with levels of ventilation in winter, 10% found it draughty and 28% found it stuffy. In the follow-up survey 75% were happy with levels of ventilation in winter.

In both surveys most occupants, around 75%, were happy with daylight levels in winter and with levels of artificial lighting.

Summer

In both the initial survey and the follow-up survey only 14% of occupants said they found summer temperatures comfortable all of the time. In the initial survey 76% found office temperatures too hot some of the time, while 26% said it was too cold some of the time. In the second survey, which was conducted during an exceptionally hot week, 87% found it too hot some of the time.
A number of occupants commented that their offices were too hot on sunny days because of the sun shining through the large windows.

In the initial survey 42% of occupants thought ventilation in summer was adequate and 55% said their offices were stuffy. In the follow-up survey 87% said their office was stuffy. It must be noted that, at the time of the second survey, building work was being undertaken next door to Norton Park and a number of respondents said that this prevented them from opening windows.

Most occupants were satisfied with daylight levels in summer and with levels of artificial lighting.

Control over the environment

Only 32% of respondents said the heating controls had been explained to them, but 65% said they were easy to use. Some respondents complained about their heating being controlled by thermostats situated in neighbouring offices.

The majority of respondents found the lighting controls easy to use. Some respondents complained that the automatic switch-off mechanism sometimes switched off the lights during meetings or when they were working on VDUs.

The windows at Norton Park are large and heavy. Only 12% of respondents found them easy to open and close. Forty-six percent found them difficult to use and have to call maintenance staff to help open and close the windows.

DESIGN LESSONS

The Norton Park development is exemplary in a number of ways. When well-managed, its total energy consumption is lower than the good practice consumption for an equivalent building cited in ECON 19. Gas consumption is slightly above that of the good practice benchmark cited in ECON 19 but electricity is below that of the good practice benchmark.

The redevelopment has preserved a listed building, brought employment into a run-down area of Edinburgh and it provides low-cost accommodation of a high standard for voluntary organisations. High environmental standards have been employed in all areas of the redevelopment.

The project to provide accommodation for voluntary-sector organisations would not have been financially viable if it had been necessary to find and purchase land in a suitable area and build new offices.

The initial problems with the building's energy management systems resulted in high levels of energy consumption. However, these problems have now been overcome and the building functions as intended with low energy consumption.

This demonstrates the need for energy efficiency to be carried through to the commissioning and management of the building – when these areas were addressed energy consumption fell by 40%.

The tenant survey shows the impact of proper commissioning and management on the comfort and satisfaction of occupants. Although the energy consumption of the building is low, it is still higher than was anticipated at the design stage. The building was intended to be highly insulated with high levels of insulation lining the walls and in the ceiling and with the installation of secondary glazing. A thermographic survey identified significant leakage of cold air into the building through the secondary glazing plus some areas of the walls and ceiling where insulation was defective. This could account for the higher-than-anticipated gas use.

The window design makes the windows hard to close properly and this could exacerbate the heat loss. The losses through the windows, walls and ceiling show the importance of careful detailing and supervision of the construction process.

COSTS AND FUNDING

The refurbishment of the Norton Park Building cost a total of £2 837 000 including fees. This is equivalent to £756/m^2 – much cheaper than an equivalent new building. The project was initially funded by the Tudor Trust.

Further project funding was then raised from:

- The National Lottery Charities Board
- The National Lottery Heritage Fund
- Historic Scotland
- Lothian and Edinburgh Enterprise Ltd
- Urban Aid
- TSB Foundation for Scotland
- Scottish Office Social Work Services Group
- Esmee Fairbairn Charitable Trust
- Dulverton Trust.

Some of this funding was only available because the project involved the refurbishment of a historic building.

BUILDING DATA

Design team		**Gross floor area (m^2)**	3000
Architect	Burnett Pollock Associates		
		Occupancy	300
M&E Consulting Engineer	Ove Arup	**U-values (W/m^{2}K)**	
		Walls	0.20
		Roof	0.10
Project Manager	EC Harris	Windows	0.85

REFERENCES AND FURTHER INFORMATION

REFERENCES

[1] ***Energy Efficiency Best Practice programme.*** Energy Consumption Guide 19. 'Energy use in offices'. EEBPp, London, 1998

FURTHER INFORMATION

BRE

- BRE Digest 399. Natural ventilation in non-domestic buildings

British Standards Institution

- BS 5925. Code of practice for ventilation principles and designing for natural ventilation

BSRIA

- TN11/95. Control of natural ventilation

Chartered Institution of Building Services Engineers

- Applications Manual AM10. Natural ventilation in non-domestic buildings

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME PUBLICATIONS

The following publications are available from the Energy Efficiency Best Practice programme. Contact details are given below.

General Information Report

30 A performance specification for the Energy Efficient Office of the Future

New Practice Case Studies

102 The Queens Building, De Montfort University – feedback for designers and clients
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115 The Ionica Building, Cambridge – feedback for designers and clients
124 The Edinburgh Gate Building, Harlow – feedback for designers and clients

This Case Study is based on material drafted by Databuild under contract to BRECSU for the Energy Efficiency Best Practice programme. BRECSU and Databuild would like to thank the staff of the Albion Trust and Burnet Pollock Associates for their assistance in this study.

The Government's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at **www.energy-efficiency.gov.uk**
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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

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General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.